

## DYNAMIC RESERVOIR CHARACTERIZATION THROUGH THE USE OF SURFACE DEFORMATION DATA

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### RESEARCH OBJECTIVES

The objective of this project is to develop and characterize a reservoir through the use of surface-deformation data, such as displacement and surface tilt induced by pumping or injection. Obtaining such data can be a cost-effective way of gathering information on reservoir flow geometry, which is critical for successful reservoir management.

### APPROACH

When fluid is produced from or injected into a reservoir, it causes volume changes in the reservoir, which in turn induce displacements on the ground surface. If a preferential flow path such as a fault zone exists in the reservoir (which is often the case in geothermal reservoirs), flow will occur mostly along the fault. Observations of surface deformation can be used to estimate the distribution of the volume changes in the reservoir. For

example, a vertical fault zone would produce a linear trough in the inverted image. The larger the volume change is at a particular location, the more likely fluid has moved in or out of the location. The distribution of volume change is tightly coupled with that of the reservoir flow properties: permeability and compressibility.

Surface expression of such reservoir dynamics can be monitored by using high-precision tiltmeters, global positioning systems, laser level gages, and InSAR (Interferometric Synthetic Aperture Radar). Monitoring of the deformation at or near the surface costs very little compared to drilling a large number of boreholes and instrumenting them with pressure sensors. This remote-sensing approach also provides independent data on reservoir dynamics that can be used to confirm or refute a reservoir model based on the borehole data alone.

### ACCOMPLISHMENTS

In 2000, a total of some 24 tiltmeters were used to monitor surface tilts at the Okuaizu Geothermal Field in Japan. Monitoring was timed to coincide with a scheduled field-wide maintenance, at which time all the production and re-injection wells were shut-in. The inversion results (Figure 1) indicated that the volume change at depth parallels a known fault. We also inverted InSAR data from the Coso Geothermal Field and showed that the use of both ascending- and descending-orbit InSAR data is advantageous for obtaining better resolution of subsurface volume change.

### SIGNIFICANCE OF FINDINGS

We have shown that surface deformation data such as tilt and InSAR data can be utilized to characterize the dynamics of deep reservoirs.

### RELATED PUBLICATION

Vasco, D.W., C. Wicks, and K. Karasaki, Geodetic imaging: High-resolution reservoir monitoring using satellite interferometry, *Geophys. J. Int.*, 2001 (in press).

Vasco, D.W., K. Karasaki, and O. Nakagome, Monitoring reservoir production using surface deformation at the Hijiori test site and the Okuaizu geothermal field, Japan, 2001, *Geothermics*, 2001 (submitted).

### ACKNOWLEDGMENTS

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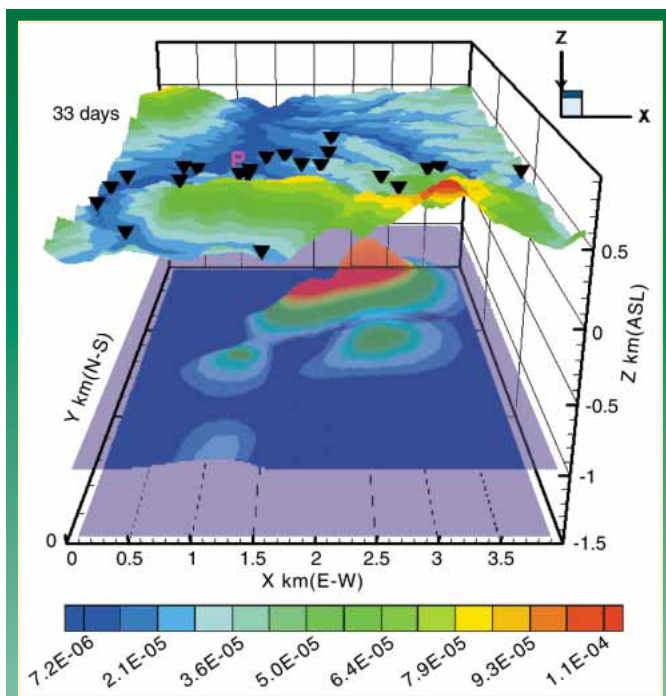


Figure 1. 3D perspective view of the inversion results. Triangles show the tiltmeter locations. The fractional volume increase at depth parallels a known fault.